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Status of Atlantic Salmon (*Salmo salar* L.) in Gander River, Notre Dame Bay (SFA 4), Newfoundland, 1995

by

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Abstract

The status of Atlantic salmon in Gander River in 1995 was determined using counts of small and large salmon from a counting fence located on the main stem just above head of tide, recreational fishery data, and biological characteristics information. The assessment was conducted in relation to the five-year moratorium on the commercial Atlantic salmon fishery, which entered its fourth year in 1995. The proportion of target egg deposition requirement achieved in 1995 was 93% which compares to 112% in 1992, 135% in 1993, 89% in 1994, and 33-36% for the period 1989-91. Numbers of small salmon spawning during 1989-91 were the lowest recorded since 1974. There was a significant decline in estimated total population sizes of small salmon during the period 1974-95. Recruitment during 1989-95 was among the lowest in the time series. The number of recruits per spawner for 1995 was the highest since 1988, probably the result of increased sea survival. Anticipated returns of small salmon in 1996 will be below target requirement, without a recreational fishery. For the period June 17 - July 5, of the small and large salmon examined, 16.9% and 46.1% possessed net marks.

Résumé

L'état du stock de saumon de l'Atlantique de la rivière Gander a été examiné en 1995 à l'aide de décomptes des petits et gros saumons à une barrière de dénombrement située sur le cours principal de la rivière tout juste en amont de la limite de la marée, ainsi qu'à partir des données de la pêche récréative et de paramètres biologiques. L'évaluation a été réalisée dans le cadre du moratoire de cinq ans imposé à la pêche commerciale du saumon de l'Atlantique dont la quatrième année débutait en 1995. La ponte cible requise a été atteinte à 93 % en 1995, comparativement à 112 % en 1992, 135 % en 1993, 89 % en 1994 et de 33 à 36 % au cours de la période 1989-1991. Le nombre de petits géniteurs estimé pour la période 1989-1991 a été le plus faible noté depuis 1974. On a décelé une baisse appréciable de l'effectif total estimé de petits saumons au cours de la période 1974-1995. Le recrutement de la période 1989-1995 est l'un des plus faibles de la série chronologique. Le nombre de recrues par géniteur estimé pour 1995 est le plus élevé depuis 1988, sans doute à cause d'une meilleure survie en mer. Les remontées prévues de petits saumons en 1996 sont inférieures aux valeurs cibles, en l'absence d'une pêche récréative. Des petits et gros saumons examinés entre le 17 juin et le 5 juillet, respectivement 16,9 % et 46,1 % présentaient des marques de filet.

Introduction

The Gander River, with a drainage area of 6,398 km^2 (Porter *et al.* 1974), is the third largest in insular Newfoundland. The river is located in Salmon Fishing Area (SFA) 4 (Notre Dame Bay) (Fig. 1). In addition to being one of the most important Atlantic salmon angling rivers in insular Newfoundland, the river has historically supported a relatively large angler guiding and outfitting industry.

In 1989, in response to concerns from angler groups that returns to the river were declining, the Department of Fisheries and Oceans in cooperation with the Gander Rod and Gun Club and the Gander Bay-Hamilton Sound Development Association, initiated a 3-year study to determine the status of the Gander River Atlantic salmon population. The results of this study (O'Connell and Ash MS 1992) showed that for the period 1989-91, Gander River received only 33-36% of target spawning requirement.

In this paper we examine the status of Atlantic salmon in Gander River in 1995, the fourth year of the commercial fishery moratorium. Counts obtained from a counting fence are used in conjunction with recreational fishery data and biological characteristics data to calculate total river returns and egg deposition. Status of stock is evaluated against a target spawning requirement (calculated in terms of fluvial and lacustrine habitats) derived for Gander River. An analysis of trends in the numbers of small salmon recruits and spawners for 1974-95 is provided as well as anticipated adult returns in 1996.

Management Measures

In 1992, a major change was introduced in the management of Atlantic salmon. A five-year moratorium was placed on the commercial fishery in insular Newfoundland while in Labrador, fishing continued under quota. In addition, a commercial license retirement program went into effect in both insular Newfoundland and Labrador. In the recreational fishery, in 1992 and 1993, a quota on the number of fish that could be retained was introduced in each SFA. The quota was assigned for each SFA as a whole and not administered on an individual river basis. Only hook-and-release fishing was permitted after the quota was caught.

In 1994, recreational fishery quotas were eliminated. In place of quotas, for insular Newfoundland, the season bag limit for retained small salmon was lowered from eight to six fish, three to be caught prior to July 31 and three after that date. After the bag limit of three was reached in each time period, hook-and-release fishing only was permitted. These measures remained in effect in 1995. As in previous years, retention of large salmon was not permitted in insular Newfoundland. In 1995, there was a fall hook-and-release fishery in the main stem of the Gander River below Gander Lake, from September 9 to October 8.

Methods

Recreational catch and effort information and counts of adult salmon in 1995 were compared to two pre-salmon moratorium means (1984-89 and 1986-91) and to the 1992-94 mean during the moratorium. The 1984-89 mean corresponds to years under major management changes in the commercial fishery in the Newfoundland Region (see O'Connell *et al.* 1992a). In 1990 and 1991, the commercial fishery in all SFAs of the Newfoundland Region was controlled by quota (O'Connell *et al.* MS 1992b). The mix of management measures in effect during 1984-89 on the one hand and the imposition of commercial quotas in 1990 and 1991 on the other, should be kept in mind when making evaluations based on the 1986-91 mean. The complete closure of the commercial fishery in 1992 was the most significant management change to date for Atlantic salmon. All the above measures were aimed at increasing river escapements. Also, a moratorium on the Northern Cod Fishery was implemented in early July of 1992, which should have resulted in the elimination of by-catch in cod fishing gear. The cod moratorium continued in 1995.

ADULT SALMON COUNTING EQUIPMENT

Adult Atlantic salmon were counted with two separate closed-circuit television (CCTV) fish counting systems installed in the counting fence. A positive image system was operated in the boat passage and counts obtained by viewing VTR tapes. Visual counts were simultaneously conducted in the boat passage and these corroborated the CCTV counts. A VTR based silhouette imaging and counting system (Pippy *et al.* MS 1996) was installed outside of the adult trap continuous with the upstream release gate from the trap. This system was operated from July 5 to September 4 and provided both counts and fork length measurements.

RECREATIONAL FISHERY DATA

Catch and effort data from the recreational fishery in Gander River were collected by Department of Fisheries and Oceans (DFO) Officers and processed by DFO Science Branch personnel. Procedures for the collection and compilation of recreational fishery data are described by Ash and O'Connell (1987). The year 1987 was not included in the means because portions of the river were closed to angling for an extensive period due to drought conditions.

BIOLOGICAL CHARACTERISTICS

Biological characteristics information on adult Atlantic salmon in Gander River was obtained by sampling recreational catches. For fish < 63 cm in length (small salmon), information used in the calculation of egg deposition was as follows:

Year	Weight (kg)			Proportion Female (N)
	Mean	SD	N	
Prior to 1992	1.63	0.37	1217	0.78 (1217)
1992	1.78	0.44	87	0.61 (87)
1993	1.85	0.39	73	0.70 (73)
1994	1.83	0.46	101	0.73 (101)
1995	1.70	0.52	49	0.67 (49)

For fish ≥ 63 cm in length (large salmon), mean values for all available data for Gander River and Terra Nova River combined were used (female mean weight = 3.41 kg, SD = 1.41, N = 16; proportion of female = 0.88, N = 16).

Fecundity was determined from ovaries collected in the recreational fishery. Ovaries were stored in Gilson's fluid until ovarian tissue had broken down after which time eggs were transferred to 10% formalin. Eggs, which for the most part were in early stages of development, were counted directly. The relative fecundity value used to calculate egg deposition for both small and large salmon was 1,665 eggs/kg and represented all data combined for the years 1984-87 (N = 173).

TOTAL RIVER RETURNS, SPAWNING ESCAPEMENT, AND EGG DEPOSITION

Calculations were performed for small and large salmon separately. Total egg deposition was obtained by summing depositions for small and large salmon.

Total River Returns

Total river returns (TRR) was calculated as follows:

$$TRR = RC_b + C \qquad (1)$$

where,

RC_b = recreational catch below counting fence
C = count of fish at counting fence

A partial count of small and large salmon was obtained at the counting fence in 1992. High water levels caused a delay in counting fence installation until July 1. During the period of delay, fish were counted upriver at the Salmon Brook fishway and also there were some angling catches. The numbers of small and large salmon entering Gander River prior to July 1 in 1989 and 1990

represented on average 4.8% and 7.5% of the total counts. The total counts of small and large salmon for 1992 were adjusted using these percentages. The percentage for 1991 was not used because in that year timing of adult migration was later than in 1989 and 1990 (O'Connell and Ash MS 1992). A similar approach was used to adjust the counts of small and large salmon at the Salmon Brook fishway in 1990. In that year, counts were not obtained during the last two weeks of the run prior to the cessation of counting operations because of extremely low water conditions. The average percentage of small and large salmon counted at the fishway up to August 16 during the period 1984-91 (exclusive of 1987) was 95 and 90.

Spawning Escapement

Spawning escapement (SE) was calculated as follows:

$$SE = FR - RC_a \qquad (2)$$

where,

FR = fish released from counting fence
RC_a = recreational catch above counting fence

Egg deposition

Egg deposition (ED) was calculated as follows:

$$ED = SE \times PF \times RF \times MW \qquad (3)$$

where,

SE = number of spawners
PF = proportion of females
RF = relative fecundity (No. eggs/kg)
MW = mean weight of females

The phenomenon of atresia has been reported to occur in Atlantic salmon in the Soviet Union (Melnikova 1964) and in France (Prouzet *et al.* 1984). Recently there is evidence to show that it can occur to varying degrees in insular Newfoundland (O'Connell and Dempson, unpublished data). Since the egg deposition calculations above were based on eggs in early stages of development, they should be regarded as potential egg depositions.

TARGET SPAWNING REQUIREMENT

The target spawning requirement for Gander River was developed by O'Connell and Dempson (MS 1991). The egg deposition requirement for classical fluvial parr rearing habitat (Elson 1957) was

240 eggs/100 m^2 (Elson 1975); the requirement for lacustrine habitat was 368 eggs/ha (O'Connell and Dempson 1995). **It should be noted that Gander Lake was not included in the calculation of the egg deposition requirement.**

Accessible rearing habitat and target spawning requirement for Gander River (O'Connell and Dempson 1991) were as follows:

	Lacustrine	Fluvial	Total
Accessible habitat	21,488 ha	159,560 units	
Eggs (No. x 10^6)	7.917	38.294	46.211
Small salmon (No.)	3,739	18,089	21,828

The target spawning requirement was calculated in terms of small salmon only. Egg deposition from large salmon was considered as a buffer to the estimate of spawning requirement.

NUMBER OF RECRUITS AND SPAWNERS, 1974-95, AND ANTICIPATED RETURNS IN 1996

It is possible to retrospectively estimate total population size of small salmon (or total number of small salmon recruits), prior to any exploitation, in rivers with counting facilities and to use the ratio of recruits to spawners to estimate anticipated returns one year in advance. A calculation of anticipated total returns (small plus large salmon) is also possible. Details of the calculations are presented below.

Since the implementation of the commercial fishery moratorium in 1992, the total number of small salmon recruits (TNR) for Gander River was equivalent to TRR (equation 1). Prior to 1992, TNR was calculated using a commercial fishery exploitation rate (μ_c) of 0.60 (Anon. MS 1990) according to the equation

$$TNR = TRR/(1 - \mu_c) \qquad (4)$$

For the period 1974-88, i.e., prior to the counting fence, TRR was calculated as the ratio of total recreational catch (RC_t) and the average recreational fishery exploitation rate (μ_r) for the period 1989-91 (prior to recreational quotas) of 0.158, or

$$TRR = RC_r/\mu_r \qquad (5)$$

Age composition of Gander River smolts (data for all years combined N = 1543) was adjusted to reflect only the 3+ and 4+ age groups, i.e., the minimal numbers of 2+ and 5+ year old smolts present were not considered; the resultant proportions of 3+ and 4+ smolts were 0.37 and 0.63,

respectively. The ratio of recruits to spawners (R/S) was calculated incorporating smolt age composition of small salmon according to the equation

$$R/S = [(TNR_{i+5} \times 0.37) + (TNR_{i+6} \times 0.63)]/SE_i \quad (6)$$

where,

TNR_{i+5} and TNR_{i+6} = small salmon recruits in years i+5 and i+6
SE_i = spawning escapement (small salmon) in year i

Anticipated returns of small salmon (AR_s) in 1996 was calculated as the product of the average R/S and SE for each smolt-age grouping separately and then summed. The average R/S for 1992-95 was used for both the 3+ and 4+ smolt-age groups. The equation to derive AR_s was as follows:

$$AR_s = (R/S\_3+_i \times SE_{i-5}) + (R/S\_4+_i \times SE_{i-6}) \quad (7)$$

where,

R/S_3+_i and R/S_4+_i = number of small salmon recruits per spawner with smolt ages 3+ and and 4+ in 1995 (year i)
SE_{i-5} and SE_{i-6} = spawning escapement (small salmon) in years i-5 and i-6

A similar calculation was performed with the minimum and maximum R/S corresponding to the mean for each smolt-age grouping to obtain an estimate of the range of anticipated returns.

Total anticipated returns (AR_t), or the sum of small and large salmon, was determined as follows:

$$AR_t = AR_s/P\_AR_s \quad (8)$$

where,

P_AR_s = mean proportion of small salmon in escapements for 1992-94

A measure of the precision of estimates of anticipated returns of small salmon was obtained by applying the average R/S for each smolt age group (from equation 7) to the appropriate spawning year, summing, and comparing the results to actual returns for 1992-95.

ANALYSIS TO DETECT RECRUITMENT OVERFISHING

Anon. (MS 1994) defined recruitment overfishing as a level of fishing mortality that reduces the ability of a population to persist, more specifically, the failure of a cohort of spawners to replace itself as a result of fishing. One way to evaluate Atlantic salmon stocks in terms of recruitment overfishing is through the examination of spawner-to-spawner relationships. Estimated numbers of spawners obtained from parental cohorts of small salmon were traced backward, beginning with the estimate of the number of spawners for the current year. Data sets were examined to see if numbers of spawners, which were made up of a range of chronological ages, were sufficient to replace the weighted sum of spawning parents of the same sea age. The appropriate weighting for historical spawners was determined from the average smolt-age distribution. This technique, demonstrating the use of the necessary lags and river-age distributions, is found in Anon. (MS 1994).

NET MARKS

Over the period June 17 - July 5, small and large salmon enumerated at the adult trap installed in the counting fence were examined for net marks. It was not feasible to continue examination for net marks once the CCTV fish counting system went into operation.

Results

Recreational Fishery

Catch and effort data are presented in Appendix 1. Catches for all years prior to 1992 represent retained catch for the entire angling season. Total catch for 1995 (retained plus released fish), effort, and catch per unit of effort (CPUE) are compared to years prior to 1992 and 1992-94. In 1992, there was no estimate of released fish during the period of retention of catch which could impact on comparisons. The total number of fish retained in 1995 is also shown. Comparison of 1994 and 1995 retained catch and effort with 1992 and 1993 provides an indication of the effectiveness of the elimination of quotas in 1994 on maintaining catch and effort at 1992 and 1993 levels. Calculation of CPUE in terms of retained fish only was not possible since effort figures apply to both retained and released fish collectively.

Total catch of small salmon (retained plus released fish) in 1995 increased over 1994 (25%), and exceeded the 1992-94 (moratorium) mean (27%). The catch in 1995 also increased over the pre-moratorium means, 1984-89 (38%) and 1986-91 (88%). Effort in 1995 increased over 1994 (8%), and the 1984-89 (46%), 1986-91 (65%), and 1992-94 (38%) means. CPUE in 1995 decreased from the 1984-89 (4%) and 1992-94 (7%) means but increased over 1994 (17%) and the 1986-91 (17%) mean. The number of small salmon retained in 1995 increased over 1994 (22%) and the quota years of 1992 (105%) and 1993(104%); the catch also increased over the means: 1984-89 (12%); 1986-91 (52%); 1992-94 (67%).

In the fall hook-and-release fishery, 30 small and 9 large salmon were released; effort expended was 158 rod days.

Counts at Counting Fence and Fishway

In 1995, the counting fence on the main stem of the Gander River operated from June 10 to September 4. Counts for the period 1989-95 were as follows (see also Fig. 2):

Year	Small salmon	Large salmon	% Large
1989	7,743	473	5.5
1990	7,520	508	6.3
1991	6,445	670	9.4
1992	18,179[1]	4,162[1]	18.6[1]
1993	25,905	1,734	6.2
1994	18,080	1,072	5.6
1995	22,002	1,121	4.8

[1]Adjusted count (see text)

The count of small salmon in 1995 increased over 1994 by 22%, the second highest of the moratorium years. The count of large salmon increased over1994 (5%) and was the second lowest of the moratorium years. The proportion of large salmon in 1995 was the lowest of the entire time series.

Counts of small and large salmon at the fishway located in Salmon Brook tributary for the period 1974-95 are shown in Table 1 and Fig. 2. The count of small salmon in 1995 increased over 1994 (65%) and the 1984-89 (49%), 1986-91 (123%), and 1992-94 (30%) means. The count of large salmon in 1995 also increased over 1994 and the means (51, 464, 849, and 38%, respectively). The proportion of large salmon for Salmon Brook in 1995 was 7% which compares to 8% in 1994 and 2, 2, and 7% for the 1984-89, 1986-91, and 1992-94 means, respectively.

Total River Returns, Spawning Escapement, and Percentage of Target Achieved

Total river returns, spawning escapements, and potential egg depositions for small and large salmon for Gander River in 1989-95 are presented in Table 2. In terms of eggs, there was a deficit to spawning requirement in 1995 (-7%). The relative contribution of large salmon to total egg deposition in 1995 was 13% which was the same as for 1994 and similar to 1993 (14%), but represented a substantial decline from 40% observed in 1992 and was below the average for 1989-91

(17%). **During the moratorium years, spawning escapement in terms of small salmon was met only in 1993.**

Trends in Total Numbers of Recruits and Spawners

The estimated number of small salmon recruits and corresponding number of spawners for each year-class are shown in Table 3 and Fig. 3A. There was a lot of variability in recruitment from a given spawning escapement. The ratio of total number of small salmon recruits to spawners (R/S) increased in 1995 and was the third highest observed (Fig. 3B). The addition of the 1995 point changed the trend from significance at $P < 0.01$ for the period 1974-94 to non-significance ($r^2 = 0.12$; $df = 20$; $P > 0.05$) for 1974-95. There was no identifiable trend in numbers of small salmon spawners (Fig. 3C). Expressing target spawning requirement in terms of small salmon adults (horizontal line in Fig. 3C), it is evident that target was achieved in 1979, 1981, and 1992. Numbers of spawners in 1992-95 compare well with higher values in the past, particularly the late 1970s and early 1980s, and represent a substantial improvement over the lows observed for 1989-91. Estimated recruitment in 1995 improved over 1994 but remained similar to the low levels observed since 1989. Since 1974, there was a significant decline ($r^2 = 0.48$; $df = 20$; $P < 0.01$) in the total number of small salmon recruits for Gander River (Fig. 3D).

Anticipated Returns in 1995

The estimated number of small salmon recruits anticipated for 1996, based on the average R/S for each smolt-age grouping is approximately 15,000; corresponding low and high values are approximately 9,000 and 21,000 (Table 3 and Fig. 3D). Assuming no recreational fishery, spawning escapement in 1996 is equivalent to the number of recruits, and as shown in Fig. 3C, the average anticipated returns is below the target requirement for small salmon; the high anticipated is just below target. An idea of the precision of these estimates for small salmon is shown in Table 3 (mean difference between estimated and observed for 1992-95 was - 22%). The variability described in Fig. 6 must be kept in mind with respect to estimates of anticipated returns.

Recruit Overfishing

During the commercial fishery moratorium years 1992-95, estimated numbers of small salmon spawners in Gander River were above the replacement (diagonal) line but remained below target requirement (horizontal line) in 1992, 1994, and 1995 (Fig. 4). The three years immediately preceeding the moratorium, 1989-91, were well below the replacement line and target requirement.

Net Marks

A total of 233 small salmon was examined. Of these, 16 (6.9%) had net marks. Also, 13 large salmon were examined and of these, 6 (46.1%) had net scarring. For small and large salmon combined, the percentage with net marks was 8.9%.

Discussion

Compared to the late 1970s and early 1980s, since 1989, the estimated total population size of Gander River small salmon has been quite low. Had there been a commercial fishery in 1992-95, total river returns and spawning escapements would probably have continued at the low level indicative of the period 1989-91. Anticipated returns of small salmon in 1995 were approximately 14,000 with corresponding low and high estimates of 9,700 and 21,000, respectively. The actual return of small salmon was 22,264. The increase in actual returns over anticipated returns is also reflected in the increase in R/S for 1995. The increase could be due in part to improved natural survival in the marine environment. The above analysis was based on fixed parameter values (smolt-age composition and commercial and recreational fishery exploitation rates) and assumes constant natural survival rates both in freshwater and in the sea. The use of constants in the prediction of adult returns is risky since the parameters are most likely subject to annual variability. For instance, smolt-adult survival has been shown to be highly variable in Northeast Brook, Trepassey (SFA 9) and Conne River (SFA 11) (O'Connell *et al.* MS 1996). Each of these rivers showed a marked increase in smolt-adult survival in 1995, while increases for Rocky River (SFA 9) and Western Arm Brook (SFA 14A) were much less, and Campbellton River (SFA 4) showed a decline. If increased natural survival was partially responsible for the higher than anticipated returns in 1995, and it is assumed that similar conditions will apply to 1996, estimated returns for 1996 based on the R/S value for 1995 instead of mean values would be 21,000 small salmon and total returns (small plus large) would be 23,300. An estimate of returns based on juvenile population estimates as indicative of abundance predicts target requirement will be exceeded in 1996 (Ryan *et al.* MS 1996). Increased returns arising from increased spawning escapements due to the closure of the commercial fishery in 1992, are not expected until 1997 or 1998 (depending on the strength of the 3+ smolt component).

In 1992 and 1993, quotas constrained the retention of small salmon in the recreational fishery to around 1,200 each year. By comparison, in 1994 and 1995, the number of small salmon retained increased to 2,122 and 2,598, respectively. The angling exploitation rate was 0.116 in 1994 and 0.117 in 1995, which compares to 0.070 and 0.049 in 1992 and 1993. The increased exploitation was most likely a function of the removal of quotas.

There are indications from observations on net-marked fish that an illegal fishery and by-catch in the marine environment and possibly illegal removals in the river river below the counting fence continued to occur in 1995. Adult returns to the river were diminished accordingly.

Cautions associated with the parameter values used to calculate the target spawning requirement have been discussed previously by O'Connell and Dempson (1995) and will not be dealt with here.

Acknowledgement

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Table 1. Counts of small and large salmon at Salmon Brook fishway, 1974-95. Partial counts are in parentheses and are not included in means. Adjusted counts are bold and in italics.

Year	Small salmon	Large salmon
1974	857	9
1975		
1976		
1977		
1978	755	52
1979	(404)	(6)
1980	997	15
1981	2459	33
1982	1425	18
1983	978	12
1984	1081	38
1985	1663	26
1986	1064	12
1987	493	9
1988	1562	24
1989	596	24
1990	***345***	***8***
1991	245	2
1992	1168	101
1993	1560	87
1994	968	83
1995	1600	125
$\bar{X}$ 84-89	1076.5	22.2
95% LCL	572.9	11.2
95% UCL	1580.1	33.2
N	6	6
$\bar{X}$ 86-91	717.5	13.2
95% LCL	190.5	3.7
95% UCL	1244.5	22.6
N	6	6
$\bar{X}$ 92-94	1232.0	90.3
95% LCL	483.9	66.9
95% UCL	1980.1	113.8
N	3	3

Table 2. Total river returns, spawning escapements, and potential egg deposition for small and large salmon for Gander River in 1989-95.

Year	Total returns (No.)		Spawning escapement (No.)		Egg deposition (No. × 10^6)		% of Target (eggs)
	Small	Large	Small	Large	Small	Large	
1989	7743	473	6570	473	13.909	2.363	35
1990	7740	508	6585	508	13.940	2.538	36
1991	6745	670	5565	670	11.781	3.347	33
1992	18179	4180	17143	4180	30.992	20.885	112
1993	26205	1734	24934	1734	53.762	8.664	135
1994	18273	1072	16151	1072	35.924	5.356	89
1995	22264	1121	19666	1121	37.295	5.601	93

Table 3. Data used to estimate total recruits and anticipated returns in 1996 for Gander River.
Smolt age distribution is 37% 3+ & 63% 4+. Recruit years are in brackets (3+ & 4+)

Spawning Year i(i+5,i+6)	Total river escapement Year i	Total recruits Year i	Spawning escapement Year i	Recruits 3+ i+5	Recruits 4+ i+6	Recruits Total	No. of recruits per spawner (R/S ratio) 3+ i+5	No. of recruits per spawner (R/S ratio) 4+ i+6	No. of recruits per spawner (R/S ratio) Total	Return yr
74 (79 & 80)	14367	35918	12100	24583	26556	51139	2.0317	2.1947	4.2264	3.1779
	18835	47088	15863	15596	45636	61232	0.9832	2.8769	3.8601	4.9949
76 (81 & 82)	15025	37563	12654	26802	21691	48493	2.1180	1.7141	3.8322	2.7674
	14361	35903	12095	12739	20266	33005	1.0533	1.6756	2.7288	2.3457
78 (83 & 84)	21089	52723	17761	11902	20215	32117	0.6701	1.1382	1.8083	1.6686
	26576	66440	22382	11872	33473	45346	0.5304	1.4955	2.0260	2.8799
80 (85 & 86)	16861	42153	14200	19659	23535	43194	1.3844	1.6574	3.0418	2.2238
	28975	72438	24403	13822	14394	28216	0.5664	0.5898	1.1563	1.3187
82 (87 & 88)	13772	34430	11599	8454	26775	35229	0.7288	2.3084	3.0373	3.7595
	12867	32168	10837	15725	12195	27920	1.4511	1.1254	2.5765	1.7880
84 (89 & 90)	12835	32088	10810	7162	12191	19353	0.6626	1.1277	1.7903	1.5277
	21253	53133	17899	7160	10623	17783	0.4000	0.5935	0.9935	1.0893
86 (91 & 92)	14943	37358	12585	6239	11453	17692	0.4958	0.9100	1.4058	1.7839
	9139	22848	7697	6726	16509	23235	0.8739	2.1449	3.0188	2.8221
88 (93 & 94)	17000	42500	14317	9696	11512	21208	0.6772	0.8041	1.4813	1.8331
	7743	19358	6570	6761	14026	20787	1.0291	2.1349	3.1640	3.3859
90 (95 & 96)	7740	19350	6585	8238			1.2510			
	6745	16863	5565							
92 (97 & 98)	18179	18179	16911							
	26205	26205	24934							
94 (99 & 00)	18273	18273	16157							
	22264	22264	19666							
96 (01 & 02)										
98 (03 & 04)										

Anticipated returns 96 based on 1992-95 mean

	R/S ratios 3+	R/S ratios 4+	Number of small 3+	Number of small 4+	Number of small Total	Total 1.11
Mean	0.9578	1.4985	5330	9867	15198	16840
Hi	1.2510	2.1449	6962	14124	21086	23365
Low	0.6772	0.8041	3769	5295	9063	10043

Comparison of observed & expected in 92-95 (uses moratorium years only)

Year	R/S ratio 3+	R/S ratio 4+	Number of small 3+	Number of small 4+	Estimated small	Observed small	Difference (Obs-Est)	Difference %
92	0.9858	1.6946	7587	21327	28914	18179	-10735	-59
93	1.0513	1.2830	15052	9875	24927	26205	1278	5
94	0.9340	1.7300	6137	24768	30905	18273	-12632	-69
95	0.8601	1.2863	5663	8451	14115	22264	8149	37
							Mean diff	-22

Fig. 1. Map showing Salmon Fishing Areas of Newfoundland and Labrador, the Gander River watershed, and the location of the counting fence (square symbol).

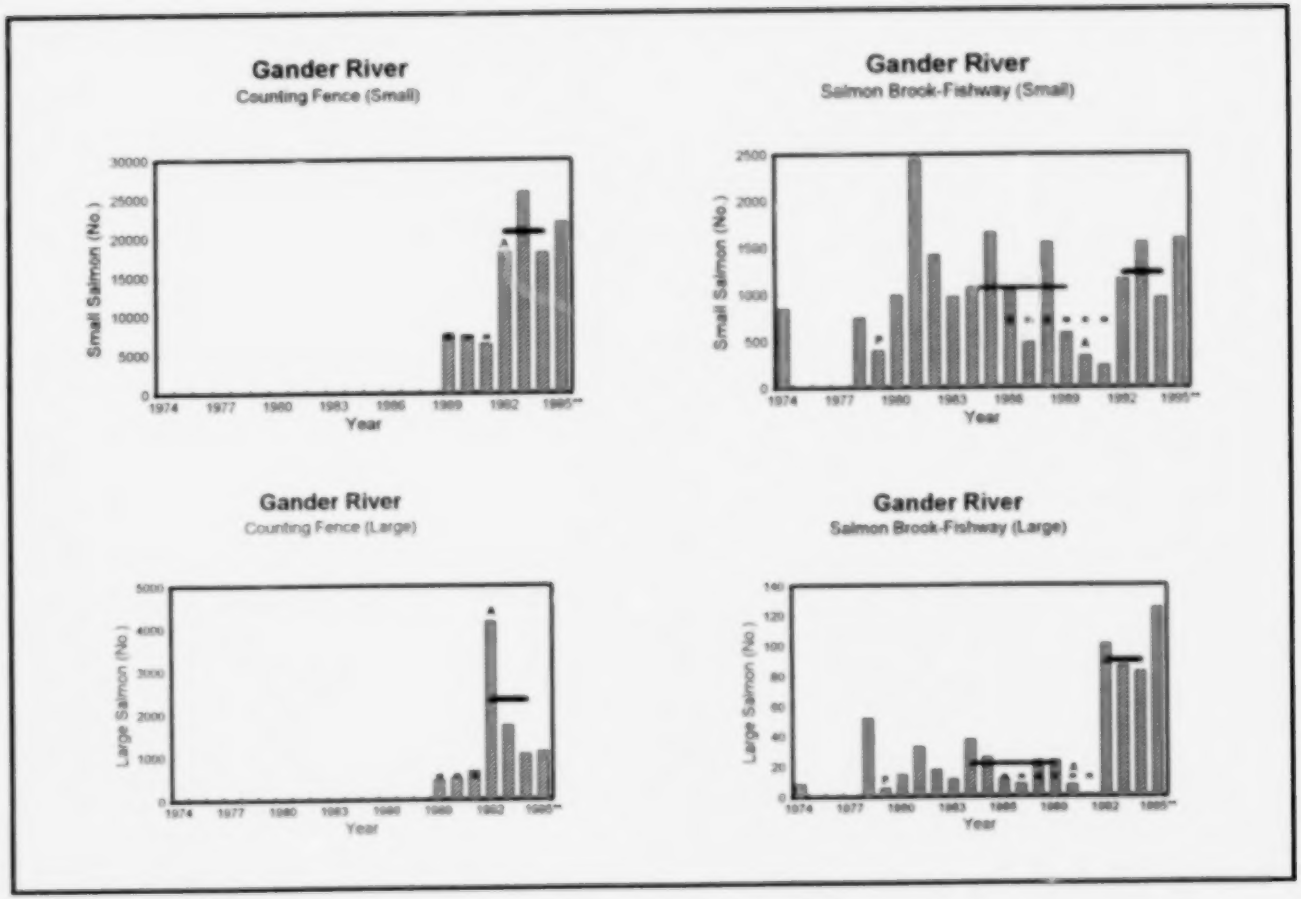

Fig. 2. Counts of small and large salmon at the Gander River counting fence and at the fishway located on the Salmon Brook tributary, 1974-95. The thin solid horizontal line represents the 1984-89 mean, the broken line the 1986-91 mean, and the thick solid line the 1992-94 mean. A = adjusted count; P = partial count, not included in the means.

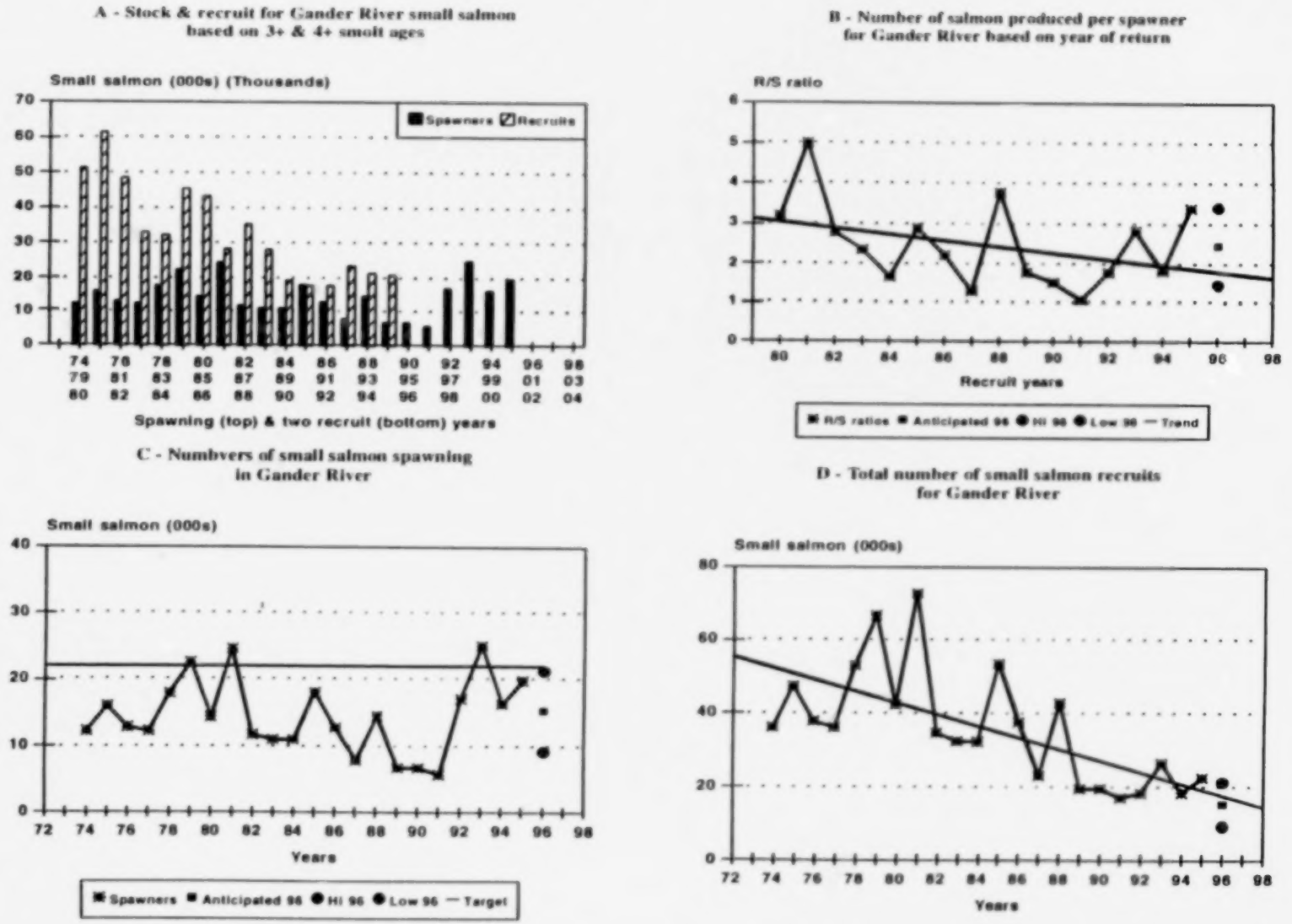
A - Stock & recruit for Gander River small salmon based on 3+ & 4+ smolt ages
Small salmon (000s) (Thousands)
Spawners
Recruits
Spawning (top) & two recruit (bottom) years
B - Number of salmon produced per spawner for Gander River based on year of return
R/S ratio
Recruit years
R/S ratios
Anticipated 96
Hi 96
Low 96
Trend
C - Numbvers of small salmon spawning in Gander River
Small salmon (000s)
Years
Spawners
Anticipated 96
Hi 96
Low 96
Target
D - Total number of small salmon recruits for Gander River
Small salmon (000s)
Years

Fig. 3. Number of small salmon spawners and recruits, lagged and totalled according to smolt age (A), number of small salmon produced (years i+5,6) per spawner (year i) (B), number of small salmon spawners, 1974-95, and anticipated spawners in 1996 in relation to target number of spawners (C), and the total number of small salmon produced (recruits), 1974-95, and anticipated total returns for 1996 (D) for Gander River.

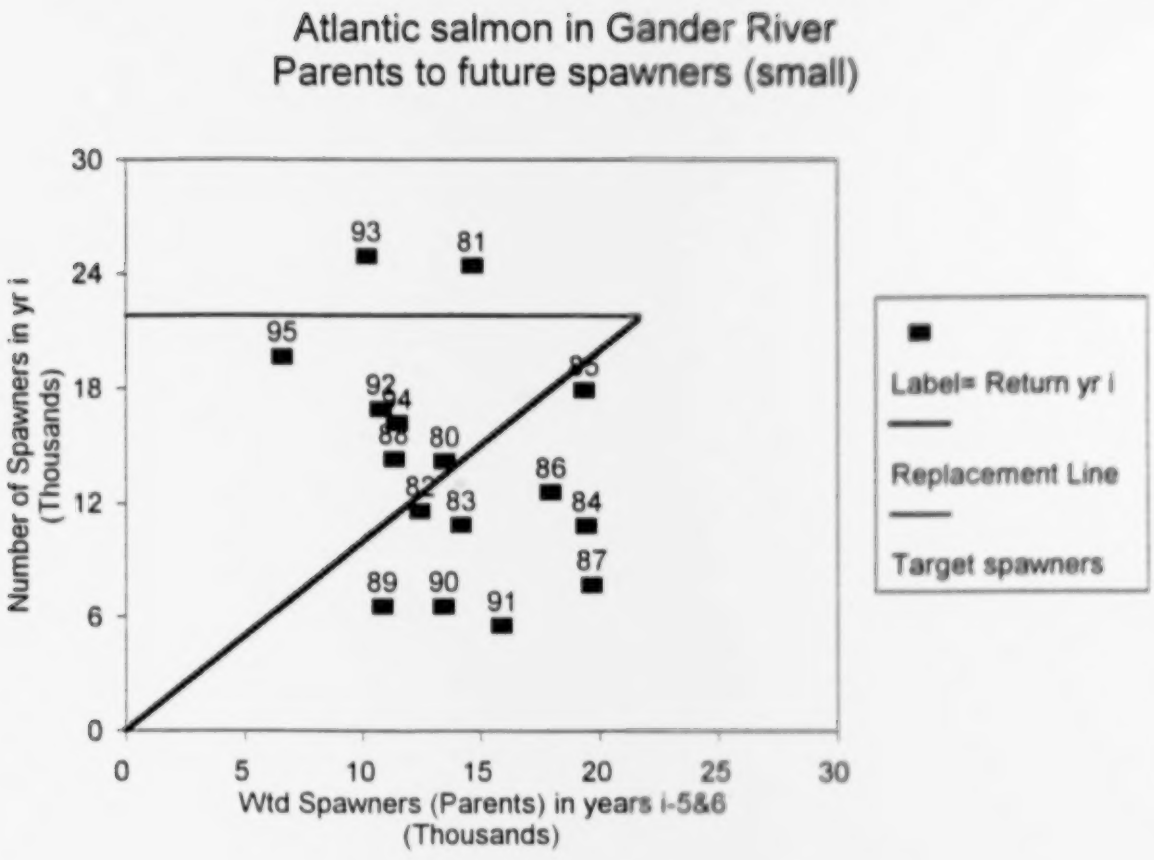

Fig. 4. The relationship between parents and spawners (after exploitation), the replacement (diagonal) line, and target spawning requirement (horizontal line) for small salmon for Gander River, 1980-95.

Appendix 1. Atlantic salmon recreational fishery catch and effort data for Gander River, Notre Dame Bay (SFA 4), 1974-1995. Ret. = retained fish, Rel. = released fish.

	Effort	Small (<63 cm)			Large (>=63 cm)			Total (Small + Large)			
Year	Rod Days	Ret	Rel	Tot	Ret	Rel	Tot	Ret	Rel	Tot	CPUE
1974	5153	2270	.	2270	19	.	19	2289	.	2289	0.44
1975	6670	2976	.	2976	38	.	38	3014	.	3014	0.45
1976	6633	2374	.	2374	132	.	132	2506	.	2506	0.38
1977	6939	2269	.	2269	927	.	927	3196	.	3196	0.46
1978	8322	3332	.	3332	389	.	389	3721	.	3721	0.45
1979	7217	4199	.	4199	318	.	318	4517	.	4517	0.63
1980	6384	2664	.	2664	268	.	268	2932	.	2932	0.46
1981	10643	4578	.	4578	249	.	249	4827	.	4827	0.45
1982	8026	2176	.	2176	205	.	205	2381	.	2381	0.30
1983	6934	2033	.	2033	239	.	239	2272	.	2272	0.33
1984	7590	2028	.	2028	13	.	13	2041	.	2041	0.27
1985	10207	3358	.	3358	*	.	0	3358	.	3358	0.33
1986	9740	2361	.	2361	*	.	0	2361	.	2361	0.24
1987	6384	1444	.	1444	*	.	0	1444	.	1444	0.23
1988	7943	2686	.	2686	*	.	0	2686	.	2686	0.34
1989	6290	1173	.	1173	*	.	0	1173	.	1173	0.19
1990	7118	1155	.	1155	*	.	0	1155	.	1155	0.16
1991	5853	1180	.	1180	*	.	0	1180	.	1180	0.20
1992	6273	1268	525	1793	*	3	3	1268	528	1796	0.29
1993	9073	1271	1950	3221	*	92	92	1271	2042	3313	0.37
1994	11287	2122	448	2570	*	39	39	2122	487	2609	0.23
1995	12215	2598	612	3210	*	74	74	2598	686	3284	0.27
84-89 $\bar{X}$	8354.0	2321.2	.	2321.2	.	.	.	2323.8	.	2323.8	0.28
95% CL	1998.7	1003.6	.	1003.6	.	.	.	1002.1	.	1002.1	0.07
N	5	5	0	5	0	0	0	5	0	5	5
86-91 $\bar{X}$	7388.8	1711.0	.	1711.0	.	.	.	1711.0	.	1711.0	0.23
95% CL	1910.7	931.9	.	931.9	.	.	.	931.9	.	931.9	0.09
N	5	5	0	5	0	0	0	5	0	5	5
92-94 $\bar{X}$	8877.7	1553.7	974.3	2528.0	.	44.7	44.7	1553.7	1019.0	2572.7	0.29
95% CL	6242.4	1222.8	2101.3	1776.1	.	111.2	111.2	1222.8	2201.6	1886.0	0.19
N	3	3	3	3	0	3	3	3	3	3	3

1987 DATA NOT INCLUDED IN MEAN.

IN THE ABOVE TABLE A PERIOD INDICATES NO DATA FOR THAT YEAR.

CPUE IS BASED ON RETAINED + RELEASED FISH FOR 1992 - 1995 AND ON RETAINED FISH ONLY PRIOR TO 1992.

* NOT ALLOWED TO RETAIN LARGE SALMON IN INSULAR NEWFOUNDLAND.